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COMMUNICATION CABLE HAVING DUAL INSULATED
CONDUCTORS

Abstract of the Disclosure

A Multi-conductor communication cable comprises a plurality of conductors insulated, firstly, with a relatively thick layer of cellular polymeric material such as polypropylene and secondly with a thin layer of solid polymeric material such as medium density polyethylene. The cable core may be filled with a petroleum jelly or other like substance and a waterproof sheath may be applied overall.

This invention relates to communication cables and more particularly to multi-conductor cables having dual insulated conductors, that is, conductors having two distinct layers of insulation. Preferably, the cable core is filled with a water impermeable substance and is enclosed within a waterproof sheath.

Multi-conductor communication cables generally consist of a number of individually insulated conductors, usually twisted into pairs, forming a core encased in a sheath comprising a 10 jacket of polymeric material, such as polyethylene. A metal shield may underly the polymeric jacket. The core is usually covered with a non-hygroscopic tape which separates the core from the metal shield, provides additional dielectric protection between the insulated conductors and shield and acts as a thermal barrier during the application of a polymeric jacket.

The interstices between the insulated conductors and other voids under a metal shield amount to about 15 to 20% of the volume within the sheath. It is possible for water entering through perforations in the sheath to fill these spaces and 20 migrate along the cable for long distances. The presence of this water degrades the electrical performance of the cable and may cause short circuits between conductors which have pinholes or other defects in their primary insulation. It may also act as an electrolyte which leads to corrosion of exposed metal surfaces directly or by facilitating galvanic action.

In recent years, the demand for a more reliable type of buried cable has led to the need for waterproof cables. Recent improvements in this area include the development of hermetically sealed sheaths.

30 An example of an hermetically sealed sheath is disclosed in Canadian Patent 678,408 to Hooker et al, issued on 21st January, 1964. There, an aluminum shielding tape is coated with



a plastic material and formed into a tube about a cable core. A thermoplastic jacket is extruded thereover; the temperature of this jacket during the extrusion process being such that the plastic coating on the aluminum tape is softened sufficiently to cause it to bond thereto. While this development has proven to be an effective way of preventing moisture from penetrating the sheath, it does not prevent moisture from entering the core should the sheath be damaged or punctured during or subsequent to installation.

10 Later developments include the art of filling the interstices between the insulated conductors in the cable core with a water impermeable medium such as petroleum jelly or an expanded polymeric material.

Known filling materials all have a relative permittivity greater than 1. Accordingly, displacement of the air from the interstices between the conductors by such filling materials result in significant changes in the electrical characteristics of the cable when compared to those of an otherwise identical unfilled cable. These changes are normally compensated for by
20 an increase in the thickness of the solid polymeric insulation on the individual conductors within the cable assembly. An increase in the insulation thickness results in an increase in the amount of material required and an increase in the diameter of the cable.

In a multi-conductor cable in accordance with the present invention, each of the conductors comprising the core of the cable has an inner layer of cellular polymeric material and an outer layer of solid polymeric material. The cellular polymeric material of this invention may be one having either a closed
30 cell structure or one having an interconnecting cell structure. Preferably, the structure of the cellular polymeric layer of this invention is closed cell.

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The interstices between the insulated conductors within the core of the cable are preferably filled with a water impermeable substance. The core may be enclosed within a helically or longitudinally applied core wrapping tape. Additional filling material may be disposed between the core wrapping tape and an overall, waterproof sheath and the components thereof.

The dual insulation combines the advantages of a reduced permittivity within the cellular layer adjacent to the conductor
10 with several advantages afforded by the addition of an overlying layer of suitable, solid polymeric material. Not only is the overall size of the cable maintained, but also a saving in material is realized by replacing solid material with cellular material. Furthermore, the dual insulating layer permits the cellular material to be "blown", i.e. expanded to very high ratios of air-to-solid material with electrical properties that make possible further reductions in the thickness of the insulation and even greater savings in material. This is of particular value with the advent of aluminum conductors which must
20 be larger in diameter than equivalent copper conductors and for which thinner layers of insulating materials are required to avoid ^{substantially} increasing the overall size of the cable.

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The pigments normally used to colour the polymeric materials are metallic-based and certain of these are known to act as catalytic agents which result in accelerated oxidation of the material. Because of the increased surface to volume ratio in an expanded insulation, an unacceptable shortening in insulation life may result if the cellular dielectric itself is coloured. This hazard is circumvented by colouring only the solid layer
30 of the composite insulation structure. The fact that the cellular insulation is unpigmented also circumvents the problem of interference of this pigment with the intended behavior of

the blowing agents and the stabilizing system of the expanded portion of the dielectric. This permits a higher degree of control during manufacture and facilitates production of a more consistant product. Also the provision of the solid polymeric outer layer inhibits migration of the filling material into the cellular dielectric which is an advantage inasmuch as it is known that certain types of filling material often affect the stabilization systems used in cellular insulations.

The use of a specific composite insulation viz unpigmented, 10 cellular polypropylene covered by a skin of coloured, solid, medium density polyethylene has been found to yield surprisingly good results over composite insulations combining other polymeric materials.

The selection of polypropylene as the cellular layer adjacent the conductor is predicated on its superior mechanical properties over other commonly used cellular polymeric materials. However, when polypropylene comes into contact with copper, for example, as a primary insulation over a copper conductor, and when such an insulated conductor is exposed to the atmosphere, it will 20 age very rapidly. Consequently, special copper inhibitor systems must be developed in order to obviate premature aging of the polypropylene. We have discovered that the need for such a specialized system is virtually eliminated and presently available stabilizing systems are more than adequate when a solid, medium density polyethylene layer is provided over the cellular polypropylene layer; that is, the thin skin of solid polyethylene inhibits premature aging of the cellular polypropylene. This is of particular advantage at splice and terminal points where the protective sheath and filling material are removed and the 30 conductors are exposed to the atmosphere.

The combination of cellular polypropylene and solid medium density polyethylene provides an insulation which is more

resistant to abrasion, cutting, buckling and similar mechanical abuse than an insulation comprising either a single cellular or dual cellular solid combination of other commonly used polymeric materials. This contributes to a higher mean dielectric strength and a narrower spread of dielectric strength levels in completed cable form.

The invention will now be described with reference to a preferred embodiment thereof as shown in the accompanying drawings in which:

10 Fig. 1 is a perspective view of a single insulated conductor forming part of a cable in accordance with the present invention; and

Fig. 2 is a partial transverse section of a communication cable in accordance with this invention.

In Figure 1, there is shown an insulated conductor 10 comprising a conductive core 12 insulated with a sheath of cellular polypropylene 14 encased in a smooth skin of solid polyethylene 16. The layer of cellular polymeric material is thicker than the layer of solid polymeric material and a specific electrical advantage is gained by limiting the thickness of the solid layer to not more than five thousandths of an inch. In this range of thicknesses, to the extent that the dielectric strength of the solid layer varies as an inverse function of its thickness, and, tends to the intrinsic strength of the material as the thickness tends to zero, normal manufacturing variations have a negligible effect on the absolute dielectric strength of the layer.

The sheath 14 contains a plurality of minute, gas-filled cells which are distributed throughout the entire body of the sheath and are substantially separated from each other by impermeable walls of polypropylene. The total volume of the cells within sheath 14 should be sufficient to reduce the bulk density

of the sheath to a value at least 20% to 40% less than that of a solid polypropylene insulation of the same thickness. Where required, higher reductions in bulk density are possible. It has been found that a reduction in bulk density approaching the level of 80% less than that of solid polypropylene has been made possible by the addition of a protective skin of solid polyethylene over the cellular sheath 14. Although the cellular polypropylene sheath 14 becomes mechanically weaker as the bulk density is decreased, the solid polyethylene skin 16 provides a smooth 10 protective surface which enhances the structural characteristics of cellular sheath 14.

The cellular sheath 14 and the solid skin 16 are formed simultaneously in a dual extrusion operation to ensure that there is a blending at the interface of the two layers. A sharply defined boundary between the cellular sheath 14 and the solid skin 16 should preferably not exist. In this way, the stress/strain characteristic of the dual insulation is improved, and by selecting a specific combination of materials, it is possible to enhance the blending of the two layers at the interface thus optimizing 20 the stress/strain characteristic of the composite insulation.

In an example embodiment, a 22 AWG aluminum conductor 12 is insulated with a cellular polypropylene dielectric 14 adjacent the conductor; expansion ratio of the cellular polypropylene being approximately 40% air and 60% polypropylene. A thickness of 9 mils has been found suitable in this application. A 2.5 mil thick skin of solid medium density polyethylene is then extruded over the cellular layer. The overall diameter of such an insulated conductor is approximately 48 mils.

Referring now to Figure 2, insulated conductors of this 30 type are incorporated into a multi-conductor filled cable. In this embodiment, a plurality of insulated conductors 10 are formed into a cable core 18. The interstices between the conductors and

other voids along the surface of the core are substantially filled with a water impermeable medium 20, such as petroleum jelly. In order to clearly illustrate the displacement of the filling material 20 within the cable core 18, the spacing between the insulated conductors 10 in the drawing has been exaggerated. A core wrap 22, in the form of a polyester tape, is applied over the filled core either helically or longitudinally, such that the edges of the tape overlap. A coating of petroleum jelly is applied over the entire surface of the wrapped core. An overall sheath 10 surrounds the coated core. The sheath comprises a metal tape applied longitudinally and folded about the core to form shield 24 and a polyethylene jacket 28 extruded over shield 24. It will be appreciated that the steps of filling the core, applying the core wrap, forming the shield and extruding the jacket may be carried out continuously and in sequence as the cable core 18 advances.

Preferably, shield 24 is a plastic coated aluminum tape which may be used to bond it to the polyethylene jacket 28. The shield 24 may be bonded at the overlap portion by virtue of the 20 plastic coating 26 resulting in an hermetically sealed shielding layer. Alternately, the shield 24 may be a copper tape similarly coated.

It will be appreciated by those skilled in the art that the conductive core 12 may be either copper or aluminum. It will also be evident to those skilled in the art that other combinations of cellular and solid insulating materials could be used in place of the cellular polypropylene-solid medium density polyethylene combination described for illustrative purposes. Where all the advantages afforded by the dual extrusion construction are not 30 required, an intermediate improvement over a single layer of conventional, cellular insulation may be achieved by exposing the cellular insulated conductor to a source of radiant heat

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maintained to a temperature substantially above the melting temperature of the cellular polymeric material. This causes the surface of the cellular layer to become partially fused, forming a dense, non-porous and glossy outer skin over the cellular layer. In this case, it would be necessary to colour the cellular polymeric material or to treat its outer surface with a colouring agent to provide identification of the conductors.

The thickness and degree of expansion of the cellular portion of the insulation represents a compromise between the 10 desired performance attributes and economic viability. Basically, the higher the degree of expansion the lower will be the relative permittivity of the cellular layer and the cost of the cable. However, correspondingly, the dielectric strength of the cellular layer is reduced as the degree of expansion is increased.

The filling material need not be petroleum jelly; it may be any water impermeable material compatible with the insulating material and with the material of the sheath while exhibiting similar dielectric properties. It must also have a high coefficient of bulk resistivity, be water-impermeable, and it must 20 not drain under the influence of gravity or other such hydrostatic pressure.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A communication cable comprising:
 - a plurality of conductors individually insulated with a dual insulation consisting of an inner layer of cellular polymeric material and a relatively thinner outer extruded layer of solid polymeric material;
 - an overall sheath surrounding said insulated conductors; and
 - a water impermeable medium disposed in and filling the interstices between said insulated conductors and between said insulated conductors and said sheath, said dual insulation having a total thickness substantially less than the thickness of an electrically equivalent single layer of solid polymeric insulation, said impermeable medium being chemically and electrically compatible with the insulating material on the conductor and the material of the sheath and being resistant to draining from the cable prior to and after installation of the cable.
2. A communication cable as defined in claim 1 wherein said layer of cellular polymeric material includes a volume of air which occupies from about 20% to about 80% of the total volume of the cellular layer.
3. A communication cable as defined in claim 2 wherein the volume of air occupies approximately 40% of the total volume of the cellular layer.
4. A communication cable as defined in claim 3 wherein said cellular polymeric material is polypropylene and said solid polymeric material is polyethylene.
5. A communication cable as defined in claim 4 wherein said conductors are aluminum.
6. A communication cable as defined in claim 5 wherein said water impermeable medium is a petroleum jelly.

7. A communication cable as defined in claim 6 wherein said sheath comprises a metal tape having on at least one surface a polymer coating; said metal tape being applied longitudinally and folded about the core; and a polyethylene jacket overlying said metal tape and bonded to the coating thereon.

8. A communication cable comprising :

a plurality of conductors individually insulated with an inner layer of cellular polypropylene and an outer layer of medium density polyethylene; said outer layer being relatively thinner than said inner layer and having a thickness not greater than five thousandths of an inch; and

an overall sheath enclosing said conductors.

9. A communication cable as defined in claim 8 wherein the total thickness of the dual insulation is substantially less than the thickness of a single solid insulation in an electrically comparable cable.

10. A communication cable as defined in claim 8 wherein said layer of cellular polypropylene includes a volume of air which occupies from about 20% to about 80% of the total volume of the cellular layer.

11. A communication cable as defined in claim 8 wherein said cellular polypropylene is unpigmented and said solid polyethylene layer is coloured.



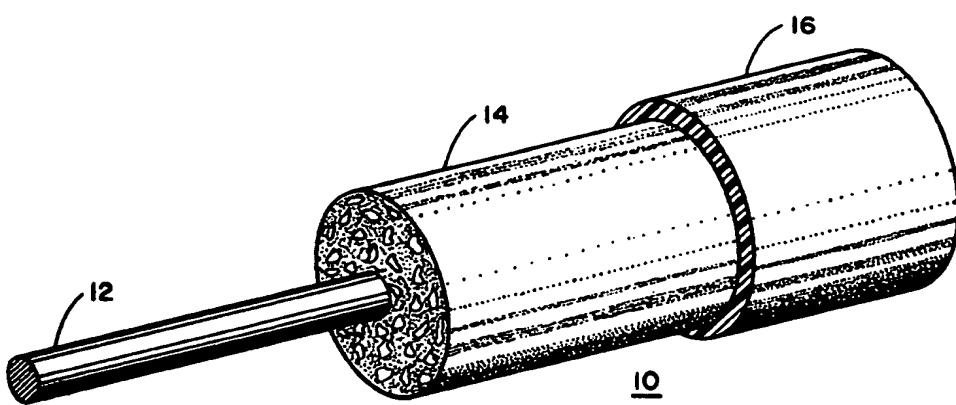


FIG. 1

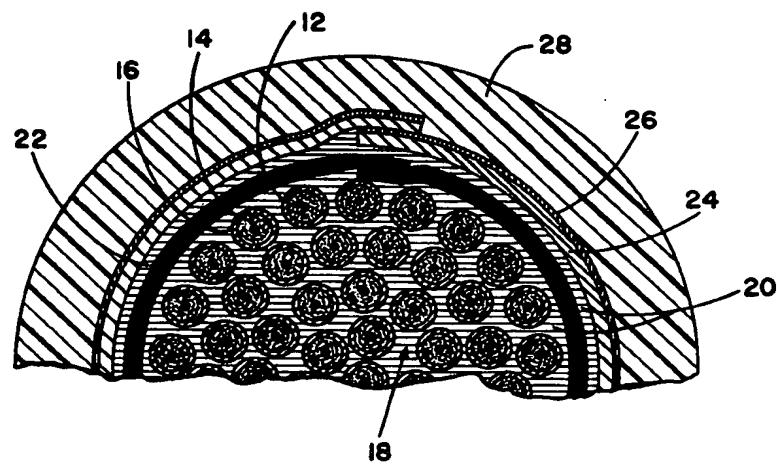


FIG. 2

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